Hello! Thanks for helping to look at this, provide thoughts and insights, etc. - it's very appreciated.

It's important that your edits are easily found. So, with that in mind, please do all edits using Track Changes.

To use track changes in Excel, click on the "review" tab. Under Review, click "Track Changes" (located in the right-most a

Then click on "Highlight Changes". This should open a box with various options.

Check the box at the top, to track changes while editing.

Then make sure that the box next to "when" is checked, and the text says "all".

Make sure the box is checked next to "highlight changes on screen".

Project Stage	General Topic	Specific Metric(s)	Analysis Already Agreed To By USAF?
Monitoring Well Installations			
Baseline Data			
	Field Data		
		Groundwater gauge data (depth to water, depth to product, product thickness)	
		Biofouling	Y
	Mapping Contaminant Locations and Concentrations		
		Locate and map LNAPL presence and depth	
		Locate and map dissolved-phase benzene presence and concentration, in excess of 5 ug/L	
		Locate and map dissolved-phase TPH presence and concentration	

Timing of Analyses	Frequency of Analyses	Location of Analyses
Before baseline geochemistry, field data, and microbial analyses performed	(Installation)	(Location of Installations)
	Once	CZ
	Once	UWBZ
	Once	LSZ
After SEE but before EBR injections or amendments	Once	New and existing MWs, located in the area to be impacted by injections/ amendments, and downgradient of this area
After SEE but before EBR injections or amendments	Once	New and existing MWs, located in the area to be impacted by injections/ amendments, and downgradient of this area

Purpose

These MWs are needed to ensure that there are sufficient MWs to evaluate the effectiveness of EBR. Neither the injection wells nor the extraction wells can be used for this evaluation. MWs are needed in suitable locations to monitor the effectiveness of EBR – otherwise, there will not be any meaningful evaluations

These data, collectively, will help establish baseline criteria against which project progress and goals can be compared.

Additional Comments

New MWs must have time to equilabrate after installation and development before baseline field data, geochemistry, and microbial analyses are performed.

7 treatment "ovals" proposed, but only 3 ovals have monitoring wells that are in reasonable locations (5/17 BCT slides)

5 initial treatment "ovals" proposed; however, only one of the first 5 "ovals" where EBR is proposed for initial implementation has a monitoring well (ST012-UWBZ24), but it is not located in an optimal location for monitoring the effectiveness of treatment (i.e., it Is not located on the path between the injection and extraction wells); 5 additional treatment "ovals," but there are no monitoring wells in these ovals (5/17 BCT slides)

15 treatment "ovals" proposed, but only 2 have monitoring wells in suitable locations. 3 additional "ovals" have monitoring wells located beyond the extraction well. Depending on how the extraction wells are pumped, sulfate may never reach these monitoring wells (5/17 BCT slides)

	Calculate total LNAPL mass is present at start of EBR	Bo/Doug - has this been done to your satisfaction already?
	Determine the amount of benzene in the LNAPL at the start of EBR	Bo/Doug - has this been done to your satisfaction already?
	Locate and map sulfate concentrations in the targeted treatment area as well as downgradient	Y
Modeling		
	Determine the time estimate for LNAPL removal	Bo/Doug - has this been done to your satisfaction already?
	Provide details of how pre-EBR LNAPL models were generated	Bo/Doug - has this been done to your satisfaction already?
	Calculate the amount of sulfate needed to maximize benzene biodegradation	Bo/Doug - has this been done to your satisfaction already?
	Provide details used to determine the sulfate calculations	Bo/Doug - has this been done to your satisfaction already?
GW Geochemistry		
	Temperature	Y
	pH	Y
	ORP value	Y
	Dissolved Oxygen	Y
	Nitrate	Y
	Ferrous Iron	
	Total Iron	
	Sulfate	Y
	Hydrogen Sulfide	

After SEE but before EBR injections or amendments	Once	

After SEE but before EBR injections or amendments	Once	New and existing MWs, located in the area to be impacted by injections/ amendments, and downgradient of this area

when compared to this baseline data, this information will help monitor for sulfate migration outside of the COC areas

Bo/Doug: Want to comment on the use of proper transport mechanisms when doing modeling? What about half-saturation comments (Doug mentioned in email dated 5/11)? benzene mole-fraction/concentration changes with time in the LNAPL ?

Reported on AF flowchart as Eh

AF decision flowchart only mentions "Iron" as an analyte, without differentiating which iron species will be monitored

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Methane	
Alkalinity	
TPH (DRO, GRO)	Y
VOCs	Y
Arsenic	Y

Indigenous Microbial Population

Total size	
Major groups within population, and their proportion of total	
Total size of sulfate-reducing bacteria	Y(?)
Total size of benzene-degrading bacteria	
In-situ benzene degradation rate	
Amount of benzene converted to biomass during stable isotope study	Y
Amount of benzene converted to carbon dioxide during stable isotope study	Y
The overall health of the indigenous microbial population, as determined via PLFA analyses	
The dominant electron-accepting process for indigenous microbial population, and reason for the conclusion	

Assessments During EBR

Field Data

After SEE but before EBR injections or amendments		In an ideal world, it would be helpful to have these samplers placed so as to monitor the core of a plume (1-2 samplers), it's periphery (1-2 samplers), and downgradient (1 sampler). These samplers cannot be used in LNAPL, but can be deployed underneath LNAPL. Any thoughts, Dan?
	Monthly for the first quarter of EBR, followed by quarterly	New and existing MWs, located in the area to be impacted by injections/ amendments, and downgradient of this area

These assessments will be used to monitor the progress of EBR, and to determine if changes to the EBR strategy need to be made. These will also help monitor progress of EBR.

These analyses will quantify the size, makeup, and health of the indigenous microbial community. All items other than the last metric are included as part of the already-proposed standard stable-isotope probe (SIP; Bio-Trap) study listed on the AF decision flowchart, but are not included in the metrics to be reported. All of these data are key to fully understanding the makeup, activities, and health of the indigenous microbial population.

AF decision flowchart references SRB gene, but Microbial Insights uses the APS gene to screen for sulfate reducers. Unclear as to what "SRB" gene is being referenced in flowchart.

Groundwater gauge data (depth to water, depth to product, product thickness)	
Biofouling	Y

Mapping Contaminant Locations and Concentrations

Locate and map LNAPL presence and depth - monitoring wells	y
Locate and map dissolved-phase benzene presence and concentration, in excess of 5 ug/L	y
Locate and map dissolved-phase TPH presence and concentration	y
Calculate total LNAPL mass is present	
Determine the amount of benzene in the LNAPL	
Locate and map sulfate concentrations in the targeted treatment area as well as downgradient	Y

Modeling

Determine the time estimate for LNAPL removal	
Provide details of how pre-EBR LNAPL models were generated	
Calculate the optimal amount of sulfate needed to maximize benzene biodegradation	
Provide details used to determine the sulfate calculations	
Assess depletion of aromatic compounds from NAPL	

During EBR		New and existing MWs, located in the area to be impacted by injections/ amendments, and downgradient of this area
	Sampling and analysis following schedule outlined in Table 4.1 of referenced document; mapping performed once per month	
	Monthly	
	Monthly	
During EBR	Quarterly (?)	

when compared to this baseline data, this information will help monitor for sulfate migration outside of the COC areas

Bo/Doug: Want to comment on the use of proper transport mechanisms when doing modeling? What about half-saturation comments (Doug mentioned in email dated 5/11)? benzene mole-fraction/concentration changes with time in the LNAPL ?

GW Geochemistry		
	Temperature	Y
	pH	Y
	ORP value	Y
	Dissolved Oxygen	Y
	Nitrate	Y
	Ferrous Iron	
	Total Iron	
	Sulfate	Y
	Hydrogen Sulfide	
	Methane	
	Alkalinity	
	TPH (DRO, GRO)	Y
	VOCs	Y
	Arsenic	Y
Soil Geochemistry		
	Continuous logging	Y
	PID readings	Y
	LNAPL Dye Test	Y
	VOCs	Y
	TPH (DRO, GRO)	Y
TEA Injection Fluid		
	ICP Metals	Y
	Sulfate	Y

Indigenous Microbial Population		
	Total size	
	Major groups within population, and their proportion of total	

During EBR	Monthly for the first quarter of EBR, followed by quarterly	New and existing MWs, located in the area to be impacted by injections/ amendments, and downgradient of this area
During EBR, following Table 5.1	During EBR, following Table 5.1	Following Table 5.1
During EBR, 6-9 months post-injection (per Decision Matrix)	Monthly, per Table 5.1 At least once during EBR	Ideally, samplers would be deployed in the same MWs as for pre-EBR analysis. This way, we're comparing apples to apples, and have eliminated any variability due to different locations. Any thoughts, Dan?

Inhibition by other degradation processes and nutrient availability are not included in the model, are these factors important? How healthy are the indigenous microbial populations? What is the dominate TEA process being used over time? If/when sulfate is no longer limiting rates of degradation, what will limit the reaction and what degradation rates can be expected?

Will periodic sulfate injections or recirculation be necessary to sustain degradation rates?
Will hydrogen sulfide concentrations inhibit degradation or will subsurface conditions mitigate their buildup?

Is benzene slower to degrade than other aromatics, or faster, or average?
To record makeup and concentration of injection fluid

These analyses will provide an indirect method of monitoring the indigenous microbial community.

Reported on AF flowchart as Eh

AF decision flowchart only mentions "Iron" as an analyte, without differentiating which iron species will be monitored
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Taken from Table 5.1, RD-RAWP Addendum 2 (March 2016)

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This data will be used to determine how the indigenous microbial community has responded to the injections/amendments and if EBR is increasing benzene biodegradation as intended. These analyses will also be a direct method to monitor the health of the indigenous population, including their response to the concentrations of sulfate being injected. Additional rounds of microbial analyses may be needed if direct or indirect monitoring data suggests.

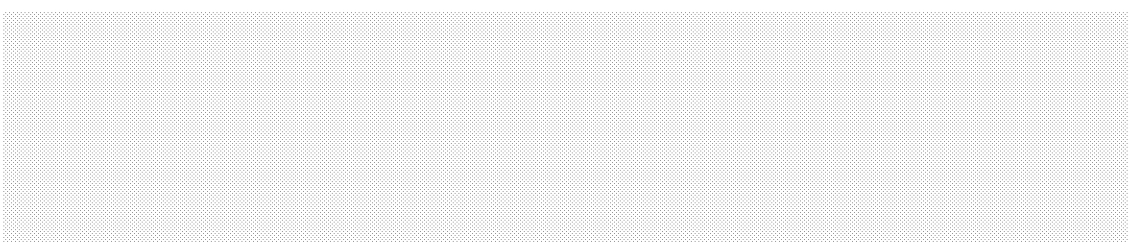
Total size of sulfate-reducing bacteria	Y (?)
Total size of benzene-degrading bacteria	
In-situ benzene degradation rate	
Amount of benzene converted to biomass during stable isotope study	Y
Amount of benzene converted to carbon dioxide during stable isotope study	Y
The overall health of the indigenous microbial population, as determined via PLFA analyses	
The dominant electron-accepting process for indigenous microbial population, and reason for the conclusion	

Injection/ Amendment Information

Location of each injection/amendment	
Concentration of sulfate at each injection/ amendment location	
Anticipated zone of influence for each injection/ amendment	
When sulfate is no longer limiting rates of degradation, what will limit the reaction and what degradation rates can be expected?	

Post-EBR Data

During EBR, for every injection/ amendment event and location



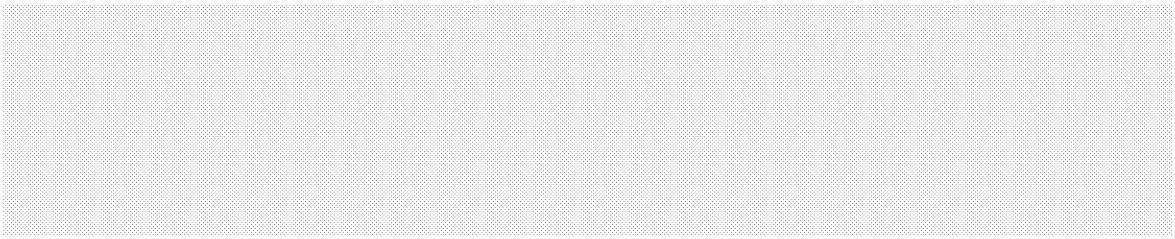
What is the lag time for SRB to acclimate to elevated sulfate concentrations (not included in the model)? Determine if highly concentrated injections of sulfate will be inhibitive to bacterial activity

Will the injected sulfate become well distributed with respect to NAPL accumulations?

This data will be compared against baseline data, and data taken during EBR, to determine the success of the project as well as to identify necessary future actions. This data will also become the baseline information used at the start of MNA

Taken from Table 5.1, RD-RAWP Addendum 2 (March 2016). AF decision flowchart references SRB gene, but Microbial Insights uses the APS gene to screen for sulfate reducers. Unclear as to what "SRB" gene is being referenced in flowchart.

This data will provide a record of exactly what was injected, where, and at what concentration. This, when compared with the response by the contaminants and other geochemical and biological data, will help determine if any changes need to be made to amendment variables such as frequency, concentration, etc.



Field Data		
	Groundwater gauge data (depth to water, depth to product, product thickness)	
	Biofouling	Y
Mapping Contaminant Locations and Concentrations		
	Locate and map LNAPL presence and depth	
	Locate and map dissolved-phase benzene presence and concentration, in excess of 5 ug/L	
	Locate and map dissolved-phase TPH presence and concentration	
	Calculate total LNAPL mass is present at conclusion of EBR	
	Determine the amount of benzene in the LNAPL at the conclusion of EBR	
	Locate and map sulfate concentrations in the targeted treatment area as well as downgradient	Y
Modeling		
	Determine the time estimate for remaining LNAPL removal	
	Provide details of how post-EBR LNAPL models were generated	
	Calculate the amount of sulfate needed to complete benzene (dissolved and LNAPL) biodegradation	
	Provide details used to determine the sulfate calculations	

Post-EBR	Quarterly, until the official start of the MNA phase of the site (??)	Each MW used for injections, amendments, or any analyses
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Post-EBR	Quarterly, until the official start of the MNA phase of the site (??)	

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GW Geochemistry

Temperature	Y
pH	Y
ORP value	Y
Dissolved Oxygen	Y
Nitrate	Y
Ferrous Iron	
Total Iron	
Sulfate	Y
Hydrogen Sulfide	
Methane	
Alkalinity	
TPH (DRO, GRO)	Y
VOCs	Y
Arsenic	Y

Indigenous Microbial Population

Total size	
Major groups within population, and their proportion of total	
Total size of sulfate-reducing bacteria	
Total size of benzene-degrading bacteria	Y (?)
In-situ benzene degradation rate	
Amount of benzene converted to biomass during stable isotope study	Y
Amount of benzene converted to carbon dioxide during stable isotope study	Y
The overall health of the indigenous microbial population, as determined via PLFA analyses	

Post-EBR	Quarterly, until the official start of the MNA phase of the site (??)	Each MW used for injections, amendments, or any analyses
Post-EBR	Once, within 3 months of the last injection/ amendment	Ideally, samplers would be deployed in the same MWs as for pre-EBR, and during-EBR analyses. This way, we're comparing apples to apples, and have eliminated any variability due to different locations. Any thoughts, Dan?

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The dominant electron-accepting process for indigenous microbial population, and reason for the conclusion